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Sampling for Airborne Radioactivity

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ABSTRACT

This report examines how to sample airborne radioactivity with minimal complexity and time expenditure, using conventional high-volume samplers in combination with alpha-particle spectrometry. The use of alpha spectrometry provides compensation for radon/thoron decay products collected on the filter paper of the sampler, leading to a seven-fold improvement in measurement sensitivity of artificial airborne alpha sources compared to simply treating radon/thoron products as a background contribution. It is estimated that high sensitivity measurements of airborne radioactivity can be made in under 30 minutes, using the procedures recommended in this report.

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Executive Summary

Airborne radioactive particles may emit alpha, beta, gamma or neutron radiation, depending on the radioisotope present. The most dangerous of these are alpha particles, since they have high energy (>4 MeV for most alpha-emitting isotopes), leading to large localised radiation doses when inhaled or ingested, compared to betas, gammas and neutrons. For an airborne radioactivity detection system, it is most important to be able to detect alpha particles and their energies, for radioisotope identification and risk evaluation.

In the event of an incident involving airborne radioactivity, it is necessary to measure the concentration of radioactive particles in the air and to identify the radioisotope present. This will allow risk evaluation, which is essential in establishing the hot and warm zone boundaries and will enable the commander at the scene to assess the level of protection that responders should adopt prior to entering the hot zone. It is important to have equipment that will provide this information accurately and in the least amount of time.

This report evaluates four high-volume air samplers to provide guidance regarding the level of measurement sensitivity achievable using conventional air sampling in combination with an alpha-particle spectrometer, such as the iSolo® alpha/beta counting system used here. Air sampling has traditionally involved collection onto a filter paper which is checked for alpha radioactivity. The problem with this approach is that short-lived radon/thoron decay products emit alpha particles with energies from 6.0 to 8.8 MeV, and act as a background which can mask the presence of other airborne isotopes. The use of an alpha spectrometer can identify which of the detected alpha particles are from radon/thoron products and provide a radon-compensated alpha particle count rate.

Conventional high-volume air samplers, using filter paper as the collection medium, can produce results in under 30 minutes. The faster the sampling rate the less sampling time is needed. It is recommended that the air flow through the sampler be at least in the range 100-2000 litres/minute, to allow enough sample to be collected over a 1 to 5 minute time period. Then after 10 minutes delay to allow decay of most of the short-lived radon product, counting of the alpha activity is performed over 10 minutes, using the energy spectrum of the alpha particles to identify the isotope and to discriminate natural radon/thoron products. This discrimination leads to an estimated factor of 7 improvement in minimum detection limit for artificially-introduced airborne alpha sources.

The high-volume air samplers tested in this study are light and compact, making them easy to deploy at short notice. One of the air samplers tested uses gelatine-coated filter papers, which would make it possible for use as a dual purpose unit, checking for radioactivity first then placing the filter in an agar petri dish for later biological analysis. The disadvantage of such a dual-purpose unit is that the air flow rate is much less than can be achieved with a faster sampler for radiation use alone.

Contents

1. Introduction

In the event of a radiological incident involving airborne particles, it is necessary to measure the concentration of radioactive particles in the air and to identify the particular radioisotope present. This information will enable an estimate of the level of risk, in order to establish the boundaries of the hot and warm zones and enable the incident controller or commander to assess the level of protection that responders should adopt prior to entering the hot zone. The boundaries and the level of protection need to be established quickly to protect the responders at the incident location. Where possible the level of protection should be balanced against the operational capacity of the wearer. For air sampling at such an incident one would choose equipment that can perform the task in the least amount of time and provide a simple yet accurate method of collection and analysis.

The purpose of this study is to assess the viability of four air samplers with various filter paper media and to recommend a method which might be used to optimise the measurement of airborne radioactive particles.

2. Airborne radioactivity

Airborne radioactive particles may emit alpha, beta, gamma or neutron radiation, depending on which radioisotope is present. From a health perspective, the most dangerous airborne particles are the alpha emitters, since the emitted alphas have high energy (>4 MeV), leading to large localised radiation doses when inhaled and/or ingested, compared to betas, gammas and neutrons. It is most important to be able to detect alpha particles and a spectrum of the alpha particle energies. This potentially allows identification of the airborne radioisotope, which is necessary for calculating the health risk of exposure. Detection of betas and gammas and their energies also helps in the identification of the radioisotope. For a given activity level, the number of radioactive atoms is proportional to the half life of the radioisotope. Consequently there is generally a greater health risk for longer-lived isotopes, which remain in the body over long periods until they are excreted, delivering potentially large radiation doses. For the same activity level, isotopes with very short half lives, such as decay products of radon gas, have comparatively few radioactive atoms and therefore deliver relatively small doses.

Air sampling has traditionally involved collection onto a filter paper which is checked for alpha radioactivity. The problem with this approach is that short-lived radon/thoron decay products emit alpha particles with energies from 6.0 to 8.8 MeV, and act as a background which can mask the presence of other airborne isotopes. The use of an alpha spectrometer can identify which of the detected alpha particles are from radon/thoron products and provide a radon-compensated alpha particle count rate.

3. Equipment

3.1 F&J H8400B high-volume portable air sampler

The first sampler tested was the F&J Specialty Products H8400B portable air sampler, shown below in Fig. 1. The sampler operates off a 24 V DC supply generated by two 12V battery modules in series. With these batteries it was found that the unit could be operated for 20 minutes before the batteries required re-charging. The batteries take 10 hours to re-charge, so it is advisable to have spares available in case further sampling is required beyond 20 minutes. The H8400B weighs only 4.3 kg and has a 102 mm diameter filter paper holder through which the air is drawn. It was operated with three different grades of glass-fibre filter paper, ranging from low efficiency FP4.0L, up to high efficiency FP4.0 paper, as listed in Table 1. For each paper the manufacturer has reported expected air flow rates in litres per minute (LPM) and collection efficiency values for 0.3 µm DOP (dioctyl phthalate) particles. These are listed in Table 1 for each paper.

Figure 1: The F&J Specialty Products Model H8400B air sampler

Table 1: The H8400B expected flow rates and collection efficiencies, as reported by the manufacturer

Filter Paper Grade	Expected Flow Rate (LPM)	Collection Efficiency for 0.3 µm DOP particles
FP4.0L	1641	13%
FP4.0M	679	98%
FP4.0	396	99.98%

3.2 F&J T8400ME high-volume air sampler

This air sampler is similar to the H8400B sampler above, but operates using 240 V mains power. This allows it to operate at higher power, so that a higher flow rate is possible through the filter papers. Just like the H8400B it has a 102 mm diameter filter paper holder. The unit is

shown in Fig. 2 below and the air flow rates and collection efficiencies reported by the manufacturer are listed in Table 2.

Figure 2: The F&J Specialty Products Model T8400ME air sampler

Table 2: The T8400ME expected flow rates and collection efficiencies, as reported by the manufacturer

Filter Paper Grade	Expected Flow Rate (LPM)	Collection Efficiency for 0.3 µm DOP particles
FP4.0L	2123	13%
FP4.0M	1358	98%
FP4.0	792	99.98%

3.3 F&J HV1SBC portable air sampler

This air sampler is an in-service instrument with one of the State Radiation Authorities, which they operate with FP4.0M filter paper. Since it is an in-service item, it is useful to make a comparison to the other air samplers tested and described in this report.

The HV1SBC sampler is similar in appearance to the F&J H8400B, with jumper cables for connection to a 12V DC battery pack. The air flow rate with a full battery charge is 160 litres/minute, and the reported collection efficiency for 0.3 µm DOP particles, using the FP4.0M filter paper, is 98%.

3.4 Sartorius MD8 airscan® air sampler

A different type of air sampler tested was the Sartorius MD8 airscan® air sampler, which is designed to collect microbiological air samples onto gelatine filter units with 80 mm diameter. The flow rate is adjustable up to a maximum of 133 litres/minute. The gelatine filter units have 3 µm pores, so that particles of size 3 µm and above are collected with high efficiency. A photo of this air sampler is shown in Fig. 3 below.

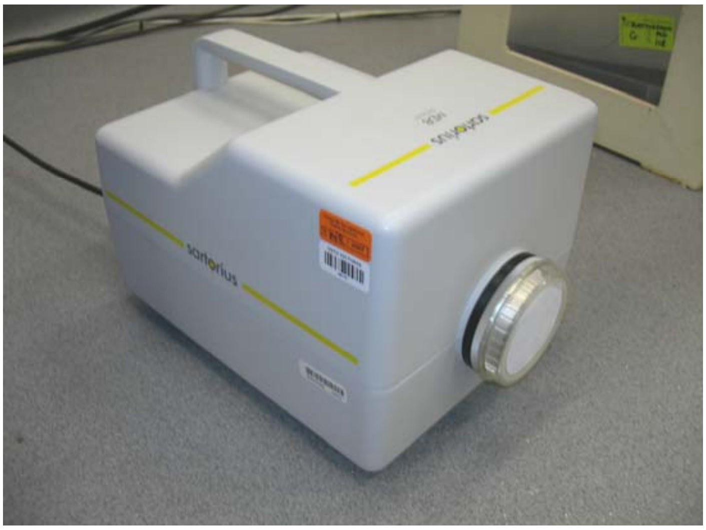

Figure 3: The Sartorius MD8 Airscan® air sampler

3.5 The Canberra iSolo® Alpha/Beta Counting System

The Canberra iSolo® alpha/beta counting system (iSolo) is designed for the analysis of air filters and smear or swipe samples. Filter papers up to 102 mm in diameter can be used. The iSolo uses a solid-state passivated implanted planar silicon (PIPS®) detector to produce an energy spectrum, which can be displayed on a front panel view screen, as well as accumulated results. The resolution of the energy spectrum is good enough to allow complete separation of alpha and beta–like events, to identify the radioisotope by the measured alpha-particle energy and to discriminate natural radon/thoron products using an automated fitting algorithm.

A photo of the iSolo is shown in Fig. 4 below. The device has good portability with a weight of less than 9 kg and can be operated for 10 hours with internal rechargeable batteries, or else mains power if available.

Figure 4: The iSolo® alpha/beta counting system

4. Equipment evaluation

4.1 Evaluation criteria

In evaluating the suitability of the equipment for sampling airborne radioactivity at the site of a radiological incident, a number of criteria should be considered. The criteria of portability, difficulty and time of set-up, collection efficiency, collection time required, analysis time, measurement precision, and minimum detection limit are discussed in Table 3 below.

Table 3. Discussion of evaluation criteria

Criteria		Comments
1.	Portability	Important since it may be necessary to carry the equipment into areas only accessible by foot. For this reason battery operation is an advantage, but mains voltage operation is also acceptable if generating equipment is available.
2.	Difficulty and time of set-up	The ability to provide a swift assessment of the radioactivity levels and isotopes present will be critical to providing an appropriately-timed response.
3.	Collection efficiency	Important to have this as high as possible, to detect a measurable signal above background in a short time frame.
4.	Collection time required	Critical, so that response decisions can be made as quickly as possible.
5.	Delay before counting and the counting time	
6.	Measurement efficiency	Important to have this as high as possible, to detect a measurable signal above background in a short time frame.
7.	Measurement precision	Desirable that this be as high as possible.
8.	Minimum detection limit	Highly dependent on the ability to differentiate between artificially-introduced radioactive particles and naturally-occurring radon transformation products. With good differentiation it is possible to achieve high levels of sensitivity and low minimum detection limits.

4.2 Equipment evaluation against criteria

4.2.1 Portability

F&J Specialty Products Model H8400B air sampler: The H8400B sampler weighs 4.3 kg and has dimensions of 238 x 241 x 264 mm, making it easy to carry and transport. It runs from an external 24 V battery supply, allowing a high degree of portability.

F&J Specialty Products Model T8400ME air sampler: The T8400ME sampler has the same weight and dimensions as the H8400B, making it easy to carry and transport. It runs from mains voltage, using ~1200 W when operated at full power.

F&J Specialty Products Model HV1SBC air sampler: The HV1SBC sampler has similar characteristics to the H8400B sampler above. Its weight and dimensions are almost identical to the other 2 models and it runs from an external 12V battery supply, allowing excellent portability.

Sartorius MD8 airscan® air sampler: This sampler weighs 6.5 kg and has dimensions of 375 x 242 x 228 mm, making it easy to carry and transport. It runs from mains voltage using 700 W of power.

4.2.2 Difficulty and time of setup

All the air samplers: The set-up procedure is minimal. For the three F&J air samplers a glass-fibre filter paper is installed at the inlet of the sampler and in the case of the Sartorius MD8 air sampler, a gelatine filter unit is installed either at the sampler inlet or at the end of a hose attached to the inlet. In all cases, a sample is collected for a selected time period at the maximum flow rate, with only a few minutes preparation. Likewise the iSolo alpha/beta counting system is simple to set up, and with calibrations previously entered can be just switched on ready for transfer of the filter paper from the sampler.

4.2.3 Collection efficiency

All the air samplers: The collection efficiency depends on the filter paper media and the sizes of the airborne particles, which for measurements in confined indoors areas vary with time over hours and days and will decrease during sampling as the larger airborne particles are selectively removed from the air by the filter paper. For filter paper with collection efficiency close to 100% the dependence on airborne particle size is expected to be minimal. Although the manufacturer has specified collection efficiency values using 0.3 µm DOP particles, it was considered desirable to test the filter papers using actual room air samples. A test was devised to establish which of the filter papers might have collection efficiency near 100%. The test involved using two layers of a particular filter paper type and measuring the relative activity collected on each. If the collection efficiency is nearly 100% then the second paper in the dual layer should have less than 1% of the activity on the first paper, and this result should be repeatable on different days when the size distribution of airborne particles may be different. One limitation of this test is that there may be some very fine particles which always pass through both filter papers.

Two of the filter papers tested had collection efficiency close to 100%, the FP4.0 and the Sartorius MD8 gelatine filter (with 3 µm pores). Both types recorded less than 1% activity on the second layer of paper compared to the front layer, in a number of different tests on different days. For both of these filter papers the collection efficiency was estimated as 99±1%.

The FP4.0L and FP4.0M filter papers did not demonstrate collection efficiency near 100%. In the test described above, the activity recorded on the second filter paper of the dual layer was always well above 1% of the activity of the front filter paper, and varied significantly in tests on different days. This indicates variations in the airborne particle sizes and that the filter papers have much less than 100% collection efficiency. For filter paper with low collection efficiency a dual layer of filter paper has a fractionating effect on the airborne particles, so that the relative activity on the two filter papers does not lead to a good measure of the collection efficiency.

For these two filter papers FP4.0L and FP4.0M, a different method for measuring the collection efficiency was devised. This involved consecutive measurements of the airborne radon/thoron decay product activity on these filter papers compared to the FP4.0 paper, used as a standard with known collection efficiency of 99±1%. For these measurements a test room was used where the activities of radon decay products were quite high, due to low levels of ventilation through the room. The activity concentration of the decay products in the room

varied in the range 20-40 Bq/m^3, depending on daily conditions. The devised method relies on the activity concentration staying relatively constant over a short period while a series of samples are collected with different filter papers, including the standard FP4.0 paper. The activity on each paper should be proportional to the product of the air flow rate and the collection efficiency, as long as the sample times are kept short, so that the activity concentrations in the room are not affected significantly by the sampling process. The Flow rate x collection efficiency values were measured by comparing the activity on each filter paper after successive 1 minute collection times. Using the FP4.0 paper as a standard, with 99±1% efficiency, the results for the other filter papers were obtained by the ratio of activities measured. The collection efficiencies can then be derived from the readings on the flow meters. The accuracy of this method is limited by the accuracy of the flow meters on the samplers, which is reported by the manufacturer to be ± 7%. For this reason, when comparing the performance of the different air sampler/filter paper combinations it is better to use the product of the flow rate and collection efficiency, which is a quantity derived from comparison of measured activity levels rather than from flow rate readings, and so does not include the additional systematic uncertainty due to the flow meters.

The measured collection efficiencies and air flow rates are shown in Table 4 below.

Table 4: The measured flow rates and collection efficiency for each sampler and filter paper

Sampler	Filter paper	Flow rate x collection efficiency (LPM)	Measured Flow Rate (LPM)	Measured Collection Efficiency
F&J H8400B	FP4.0L	190-270 (Average = 230)	1220-1240	15-22 %
	FP4.0M	410-510 (Average = 460)	620-630	65-82 %
	FP4.0	317-327 (Average = 322)	320-330	99 ± 1%
F&J T8400ME	FP4.0L	300-440 (Average = 370)	2000	15-22 %
	FP4.0M	800-980 (Average = 890)	1200-1240	65-82 %
	FP4.0	594-693 (Average = 644)	600-700	99 ± 1%
F&J HV1SBC	FP4.0M	80-100 (Average = 90)	140-160	57-63 %
Sartorius MD8 airscan®	Gelatine filters with 3 µm pores	130-134 (Average = 132)	133	99 ± 1%

4.2.4 Collection time required

The collection time is a compromise between the need to obtain good statistics and to determine the activity levels in a short time, hence the desirability of high flow rates. For comparison purposes it is instructive to calculate the time required to sample a standard effective volume, for each sampler/filter paper combination. The effective volume in this context is defined as the volume of air which flows through the filter paper multiplied by the collection efficiency. Table 5 below summarises how many minutes would be required with each sampler/filter paper combination to sample an effective volume of 1 m^3.

Table 5: Time to sample an effective volume of 1 m^3, for each sampler and filter paper

Sampler	Filter paper	Flow rate x collection efficiency (LPM)	Time to sample an effective volume of 1 m^3 (minutes)
F&J H8400B	FP4.0L	230 ± 40	4.3 ± 0.7
	FP4.0M	460 ± 50	2.2 ± 0.2
	FP4.0	322 ± 10	3.1 ± 0.1
F&J T8400ME	FP4.0L	370 ± 60	2.7 ± 0.4
	FP4.0M	890 ± 90	1.1 ± 0.1
	FP4.0	644 ± 50	1.6 ± 0.1
F&J HV1SBC	FP4.0M	90 ± 10	11 ± 1
Sartorius MD8 airscan®	Gelatine filters with 3 µm pores	132 ± 2	7.6 ± 0.1

4.2.5 Delay before counting and counting time

All the air samplers: The analysis procedure is to transfer the filter paper from the sampler to the iSolo alpha/beta counter and count for a fixed period. The iSolo automatically separates the alpha and beta events and displays the energy spectrum. Alpha particle counts from radon/thoron transformation products are compensated for in an automated procedure which is part of the iSolo firmware, allowing high sensitivity to non-radon alpha emitters. It has been found however that the compensation algorithm does not perform a perfect subtraction, but generally leaves a fraction of the activity due to radon products remaining. The performance of this compensation algorithm can be improved by introducing a short delay between the sample collection and counting of the activity on the filter paper. This delay significantly reduces the size of the peak from 6.0 MeV alphas from ^{218}Po, which has a 3 minute half-life. The reduction in this 6.0 MeV peak seems to greatly improve the fit by the radon-compensation algorithm. The peak from 7.7 MeV alphas from ^{214}Po is relatively unaffected by this 10 minute delay, since it is fed by ^{214}Pb and ^{214}Bi, which have half-lives of 27 and 20 minutes respectively.

The performance of this compensation algorithm for subtraction of the radon product contribution has been quantified by measuring the ratio of the radon-compensated activity to the total alpha activity as a function of delay time between sample collection and counting. The results are shown in Table 6 below. The data were collected using sample counting times of 10 minutes duration, which was sufficient to give good statistics at the radon levels being sampled, which is needed for good radon compensation.

Table 6: The ratio of the radon-compensated activity to the total alpha activity as a function of delay time between sample collection and counting, using 10 minutes counting time in the iSolo

Delay Between Sample Collection and Counting (Minutes)	Radon-compensated alpha activity/ total alpha activity
1	0.20-0.60 (Average = 0.35 ± 0.02)
3	0.12-0.28 (Average = 0.22 ± 0.04)
4	0.10-0.24 (Average = 0.20 ± 0.02)
10	0.03-0.14 (Average = 0.09 ± 0.01)
20	0.03-0.11 (Average = 0.07 ± 0.02)

From Table 6 it can be seen that a significant reduction in the ratio of radon-compensated alpha activity to total alpha activity can be achieved by setting a delay between sample collection and counting of about 10 minutes. Delays beyond 10 minutes do not achieve much further reduction in this ratio, so 10 minutes is seen as optimum for the delay, followed by 10 minutes sample counting in the iSolo.

4.2.6 Measurement efficiency

The measurement efficiency is the fraction of alpha particles emitted which are detected. This measurement efficiency was found to be dependent on the size of the filter paper used, since alpha particles emitted further from the centre of the paper are more likely to miss the detector. The measurement efficiency for a 50-mm Am-Be calibration source was found to be 0.337 ± 0.002. For the Sartorius MD8 airscan sampler, 80 mm filter units were used and for the F&J air samplers, the filter paper diameter was 102 mm. The relative measurement efficiency for the 102 mm and 80 mm papers was determined by comparing samples of radon product activity which were collected close together in time. The relative efficiency was 0.81 ± 0.02, which was used as a correction factor in comparing results from these two filters.

4.2.7 Measurement precision

All the air samplers: The precision of the measurement can be difficult to determine, since radon levels fluctuate markedly during the day. One way to avoid this problem is to make a series of measurements within a short time period, with each measurement only about 10 minutes apart. In this way the fluctuation in radon levels is minimised. When this was done for all the air samplers tested here, the precision was found to be high, with variations from one run to the next of less than 2%, in addition to those due to statistical error.

4.2.8 Minimum detection limit

All the air samplers: The minimum detection limit was estimated by looking at the energy region of 4-5.5 MeV, which is the alpha particle energy range for most long-lived radioisotopes. Alpha particles from radon transformation products produce a tail into this region, which is compensated for by the iSolo alpha/beta counter. Tests carried out with the iSolo have shown that the radon-compensation procedure leads to a non-zero background in

the non-radon alpha region, as explained earlier in section 4.2.5. The size of this background depends on the amount of radon product activity on the filter paper, the delay before counting the activity, and the activity counting time. As seen in Table 6, using optimised parameters of 10 minutes delay before counting and 10 minutes of counting, the background from radon products can be minimised to be in the range 3-14% of the total activity, based on data for radon levels up to about 40 Bq/m^3.

Using this background rate upper limit of 14%, a minimum detection limit can be calculated for radioisotopes other than radon, for the air samplers tested in this study, assuming that the minimum counts required for detection of a radiological agent is equal to the top end of the background range. Assuming each sampler collects an effective volume of 1 m^3 on its filter paper, for sampling times listed in Table 5, the background after radon compensation will depend on the activity of radon products in the air. Minimum detection limits of the non-radon isotopes are estimated in Table 7, for a range of radon product activities.

Table 7: Minimum detection limits, for the air samplers tested in this study, assuming an effective volume of 1 m^3 of air has been sampled, 10 minutes delay before counting and 10 minutes counting time in the iSolo, with radon contamination of 2-40 Bq/m^3.

Activity of radon products (Bq/m^3)	**Background after 10 min. delay and 10 min. counting (Bq)**	**Minimum detection limit of other radioisotopes (Bq/m^3)**
2	0.3	0.3
5	0.7	0.7
10	1.4	1.4
20	2.8	2.8
30	4.2	4.2
40	5.6	5.6

These minimum detection limits should be compared to those achievable without radon-compensation, using instead a standard alpha-particle pancake probe attached to survey equipment. In that case, the minimum detection limit is approximately the same as the radon concentration in the air, which varies with the time of day, level of ventilation, whether indoors or outdoors and is usually in the range 2-30 Bq/m^3 for Australia.[1]

5. Discussion

The use of high-volume air sampling, in conjunction with compensation for the alpha activity from radon products is critical in obtaining acceptably-low minimum detection limits in a short time frame. The product of the flow rate of the sampler and the collection efficiency determines how many minutes of sampling are required to achieve sufficient activity on the filter paper. For instance, as seen in Table 5, the F&J T8400ME sampler collects at a rate ten times faster than the F&J HV1SBC sampler, using the same type of filter paper. The use of air samplers with low collection rates should be avoided, since the collection times needed are much longer, and usually unacceptable in emergency or time-critical situations. For instance, a

1 litre/minute sampler will require 1000 minutes to collect 1 m^3, which would be unacceptable. The use of filters with low collection efficiency should also be avoided as the collection efficiency has a particle size dependence which is unknown.

Using the procedures outlined in the previous section, with a delay of 10 minutes before counting and 10 minutes counting time, the radon-compensation algorithm of the iSolo leads to a factor of 7 improvement in minimum detection limit compared to conventional alpha activity measurement. This factor of 7 is based on the fact that after the radon compensation algorithm has been applied, up to 14% of the background contribution remains. This is a worthwhile improvement, but not essential. An alternative to using the iSolo radon-compensation is to increase the delay before counting the alpha activity on the filter paper, so that the activity due to radon products is less significant. A second alternative is to accept the higher minimum detection limits.

Since the Sartorius MD8 air sampler uses gelatine filter units, designed primarily for biological sample collection, this sampler could be used as a dual purpose unit, checking the filter first for radioactivity, then placing it in an agar petri dish for preservation of any biological agents while it is sent away for laboratory analysis. However, the flow rate through the gelatine filter is lower than achievable with glass-fibre filters.

6. Recommendations

The results from this evaluation could be used to develop procedures for rapid determination of airborne radioactivity. It is recommended that high-volume air sampling be used, in combination with a system such as the iSolo alpha/beta counter for differentiating between artificial radioisotopes and natural airborne radioactivity. The advantage of using such a system is that artificial airborne radioisotopes can be detected in a short time frame (about 30 minutes) and with a low degree of difficulty.

The flow rate of the air sampler and collection efficiency should be as high as possible. This will result in low minimum detection limits in the shortest time frame. Flow rates greater than ~100 litres/minute are considered essential, with greater than 1000 litres/minute desirable. Preference should be given to mains-powered air samplers which generally have a higher power rating than battery-operated models, allowing high flow rates with fine-grade filter papers, which give collection efficiencies approaching 100%.

7. References

1. A Nation-wide Survey of Radon and Gamma Radiation Levels in Australian Homes, M.K. Langroo, K.N. Wise, J.C. Duggleby and L.H. Kotler, ARL technical report TR090, April 1990, available at: http://www.arpansa.gov.au/Publications/technicalreports/index.cfm

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19. ABSTRACT

This report examines how to sample airborne radioactivity with minimal complexity and time expenditure, using conventional high-volume samplers in combination with alpha-particle spectrometry. The use of alpha spectrometry provides compensation for radon/thoron decay products collected on the filter paper of the sampler, leading to a seven-fold improvement in measurement sensitivity of artificial airborne alpha sources compared to simply treating radon/thoron products as a background contribution. It is estimated that high sensitivity measurements of airborne radioactivity can be made in under 30 minutes, using the procedures recommended in this report.